ENVIRONMENTAL ASSESSMENT

RELATIVISTIC HEAVY ION COLLIDER
AT
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

DECEMBER 1991

DOE/EA #0508

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1.0 INTRODUCTION

Brookhaven National Laboratory (BNL) was founded in 1947 to provide a center for nuclear science in the northeastern United States. High energy physics research has been a major activity at BNL since 1952, when the Cosmotron became the first accelerator to provide protons with energies above one billion electron volts. The BNL Sitewide Environmental Impact Statement of 1977 (ERDA-1540) provides details on the programs and activities which occur at BNL and their associated environmental impacts.[1]

In 1979, BNL started construction of the ISABELLE/Colliding Beam Accelerator (CBA), a machine capable of colliding protons to produce energies of 800 GeV.[2] The only other colliding beam accelerator in existence at the time was at Geneva, Switzerland where only 62 GeV energy collisions were possible. Construction of the ISABELLE/CBA continued until 1983 when support for the project was withdrawn. At the time support was withdrawn, most conventional facilities had been completed. Although inoperative, the ISABELLE/CBA facilities have been maintained since construction was halted.

In 1983 the concept of a heavy ion collider facility, reaching center-of-mass collision energies at least 10 times higher than maximum collision energies obtainable at existing accelerator facilities, was identified as the highest priority need for a new facility in the Long Range Plan for basic nuclear research in the U.S. Immediately thereafter a panel was formed which included leading experimentalists and theorists from both high energy and nuclear physics representing the major interested laboratories throughout the U.S. and in Europe, to consider the basic design requirements for such a facility. This group formulated the essential design parameters for a relativistic heavy ion collider (RHIC) which is a machine which would incorporate the flexibility to study collisions of all nuclei from the lightest to the heaviest and allow experiments to be carried out over the full range of energies from a few GeV/amu (center-of-mass) up to the top collider energy with no inaccessible gaps in the energy spectrum, and with adequate intensity for sensitive measurements.

The technical parameters were developed for an accelerator complex which would utilize the existing facilities already in place from the ISABELLE/CBA project at Brookhaven. This environmental assessment describes the environmental impacts which might be caused by construction and operation of the RHIC at BNL.

2.0 PROPOSED ACTION

2.1 Description

The proposed action is to construct and operate a RHIC at BNL. The proposal is to utilize the existing (though unfinished) facilities already in place for the ISABELLE/CBA at BNL, plus other needed equipment, facilities, and components that exist at BNL including a Tandem Van de Graaff accelerator, Heavy Ion Transfer Line (HITL), Alternating Gradient Synchrotron (AGS), and AGS Booster, and to construct three experimental halls with support facilities, fabricate and install superconducting magnets and associated accelerator systems, and complete other construction necessary for RHIC. The RHIC facility would provide a unique world-class heavy ion research facility which would extend by at least an order of magnitude the center-of-mass collision energies available with man-made beams of nuclei.

The completed RHIC facility would receive particles from a complex set of accelerators and transfer equipment, most of which are existing experimental facilities in operation. A Tandem Van de Graaff accelerator which went into operation in 1970, would serve as the initial point of ion acceleration. Accelerated ions would then traverse the Heavy Ion Transfer Line (HITL) completed in 1986, to allow injection into the AGS Booster accelerator which became operational in May 1991. After extraction from the Booster, the ions would enter the AGS, operational since 1960, where they would be accelerated to the top AGS energy (28 GeV/c for protons; 11 GeV/amu for gold). The particle bunch would then be transferred to the collider by a magnet system which would be installed in existing transfer line tunnels. Superconducting magnets would bend and focus the ion beams within the RHIC. The pathway of acceleration is illustrated in Figure 3-1.

Construction of the ISABELLE/CBA commenced in 1979 and continued until 1983 when support was withdrawn from the project. At the time support was withdrawn, most conventional facilities had been completed. Completed facilities represent approximately 90% of the conventional construction that otherwise would be required. Proposed construction to permit the operation of the RHIC would consist of building two experimental halls with support facilities (i.e. substations, storage space, etc.), paving the ring road, fabricating and installing superconducting magnets and associated accelerator systems, rehabilitating existing berms, and instituting a planting program to control berm erosion and provide shading to the Peconic River. In conjunction with the two experimental halls to be constructed, the tunnel would be completed at these locations. Each area would require 382 feet of tunnel to connect the existing tunnel. Power distribution stations would be located at 2, 4, 6, 8, 10, and 12 o'clock positions, respectively, two stations would be adjacent two the existing collider center and one at the Beam Injection area. These stations would aid in onsite power distribution only. No additional offsite stations would be required to feed this area.

2.2 Purpose and Need

The RHIC facility's primary contribution to nuclear physics would be the ability to collide heavy ions at beam energies of up to 20 TeV, over ten times the beam energy for heavy ions of any existing or proposed facility in the world. The anticipated scientific benefits of the RHIC lie in its unique ability to create matter at extremely high temperatures and densities -- so extreme that scientists hope to observe, under laboratory conditions, phenomena that have not occurred in the natural universe since the original "Big Bang". This would make possible studies of the fundamental properties of matter in a state in which the primordial quarks and gluons are no longer confined as constituents of the nuclei of ordinary particles.

Figure 2-1: Beam Path From Point of Initial Injection to RHIC.

0 feet

Such nuclear matter is called a quark-gluon plasma. It has never been seen before, and it offers a whole new area of scientific study for physicists:

* Nuclear physicists are eager to explore a new frontier with the formation of quark matter. The transition from regular nuclear matter to a quark-gluon plasma is a very fundamental process predicted by modern theory. To test the theory, matter would have to be compressed to ten times the density of normal nuclei, or raised to a temperature one hundred thousand times hotter than the temperature at the center of the sun;

* Particle physicists would study the structure of quark matter and, for the first time, would be able to test their theories by observing systems in which large numbers of quarks interact with one another;

* Astrophysicists want to recreate the conditions that characterized the early evolution of the universe as well as study the properties of nuclear matter with the high densities found in exploding stars.

3.0 OTHER ALTERNATIVES

3.1 No-Action Alternative

The No-Action Alternative to the RHIC Project would abandon the construction/operation of a RHIC. Failure to pursue this project would not meet the facility requirements identified by the physics high energy and nuclear research communities. At BNL, failure to pursue the RHIC program would render the existing ISABELLE/CBA facilities of little future use as an accelerator and would eventually result in the demolition of facilities except for the Collider Center which provides useful office space. Currently, operating costs are expended to maintain the previously described existing ISABELLE/CBA facilities which are used to some extent as storage area. These costs include such elements as electrical energy costs to maintain heat and light. Areas such as the Service Building require, in addition to electrical costs, a budgeted amount of janitorial services and operational costs for conditioning service and security. These costs would be discontinued upon demolition of the facility. Since no beam or other equipment has been introduced into the facility which could have produced any hazardous or radioactive wastes, disposal of materials not reusable would be through current accepted practices associated with construction debris.

3.2 RHIC Construction at Another Site

Locating the RHIC at BNL would take advantage of the partially constructed, though inoperative, accelerator at the laboratory site. The BNL location would also benefit from the accessibility of the existing AGS, Tandem Van de Graaff, Linear Accelerator (LINAC) and AGS Booster. A similar complex of facilities does not exist in any other location.

Locating a RHIC elsewhere would necessitate construction of a complete ring, with the corresponding increase in expense and environmental impact. It would require the additional construction of the injector machines that exist at BNL and that are proposed for RHIC at the alternative site.

3.3 Construction of a Fixed Target Accelerator

To achieve collision energies of the magnitude intended for the RHIC, but with one high energy beam and a stationary target, would require an accelerator ring with a diameter approximately 400 times that of the proposed RHIC. Such a machine would be impractical in terms of cost, resource utilization, and environmental impact.[3]

3.4 Use of Existing Facilities for RHIC

Fermilab and SSC were considered as possible sites to determine the feasibility of conducting RHIC experimentation. Fermilab could not incorporate RHIC experimentation without the reconstruction of an injector system similar to the existing system at BNL. This construction would involve potential adverse impacts to wetlands, destruction of open space, and double construction costs projected for BNL. Fermilab operations are currently at full capacity; existing accelerator facilities could not be used without cutting back another program. The feasibility of conducting RHIC research at the proposed SSC facility was assessed. It was determined that the technical ability of a slow cycling superconducting ring to replace the rapid cycling room temperature synchrotron planned for the SSC facility is improbable. Adding the RHIC to the SSC facility would cost approximately $200 million more than the costs for the proposed RHIC at BNL.

4.0 SITE DESCRIPTION

BNL is a multidisciplinary scientific research center located close to the geographical center of Suffolk County, New York, about 97 kilometers east of New York City. A general overview of BNL is provided in Figure 4-1. About 1.36 million persons reside in Suffolk County and about 0.41 million persons reside in Brookhaven Township, within which the Laboratory is situated. Approximately 8,000 persons reside within one half kilometer of the Laboratory boundary. The distribution of the resident population within 80 kilometers of BNL for 1989 is also shown in Figure 4-2. Although much of the land area within a 16 kilometer radius remains either forested or cultivated, there has been continued residential and commercial development near the Laboratory during recent years.

4.1 Major BNL Facilities

A wide variety of scientific programs are conducted at BNL. These programs contribute to the cumulative environmental impact realized by current BNL operations. The major scientific facilities used to conduct research and development at BNL are described below:

1) The High Flux Beam Reactor (HFBR) is fueled with enriched uranium, moderated and cooled by heavy water and operated at a routine power level of 60 Megawatts thermal.

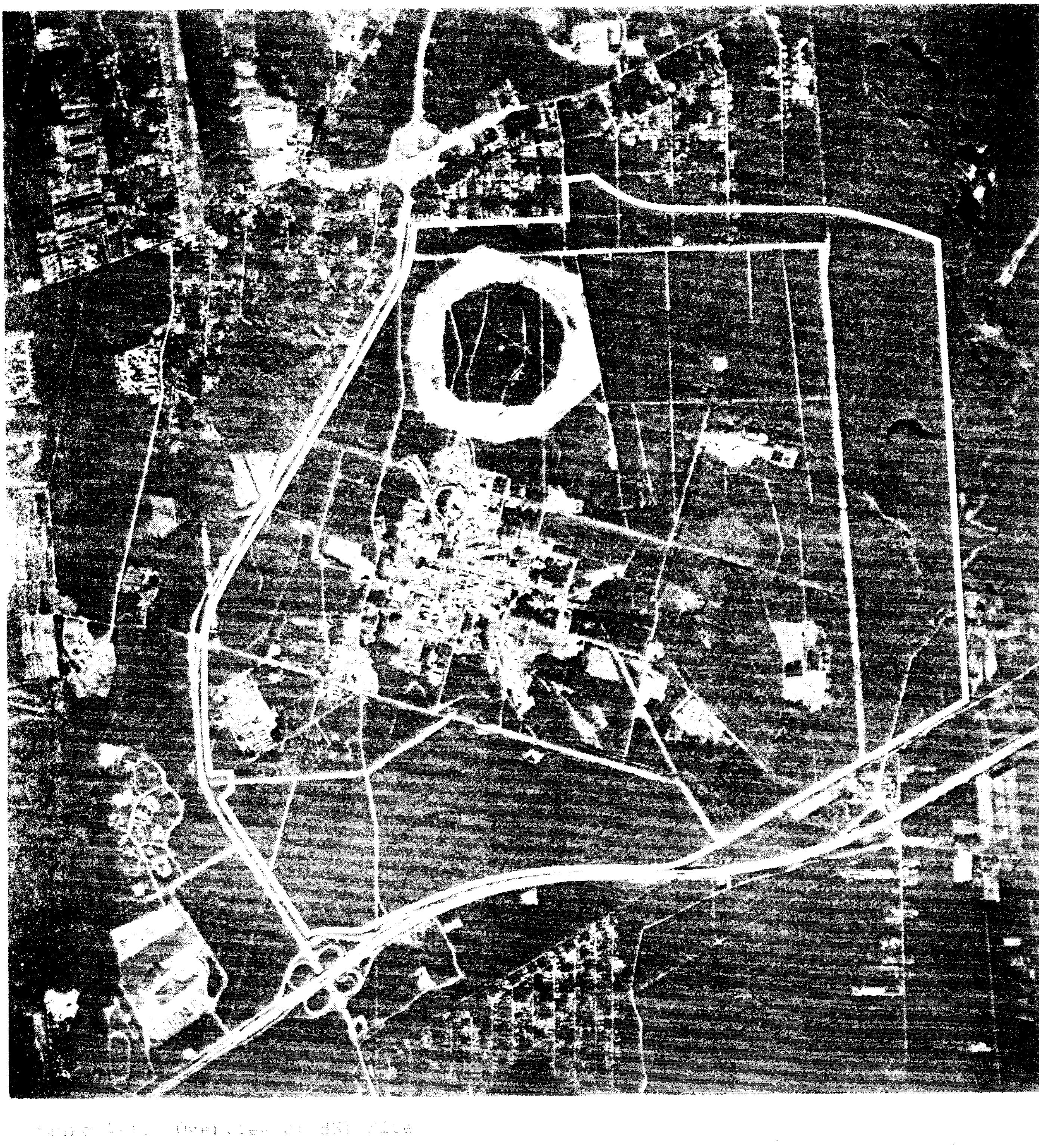

Figure 2-1. Overview of BNL Site

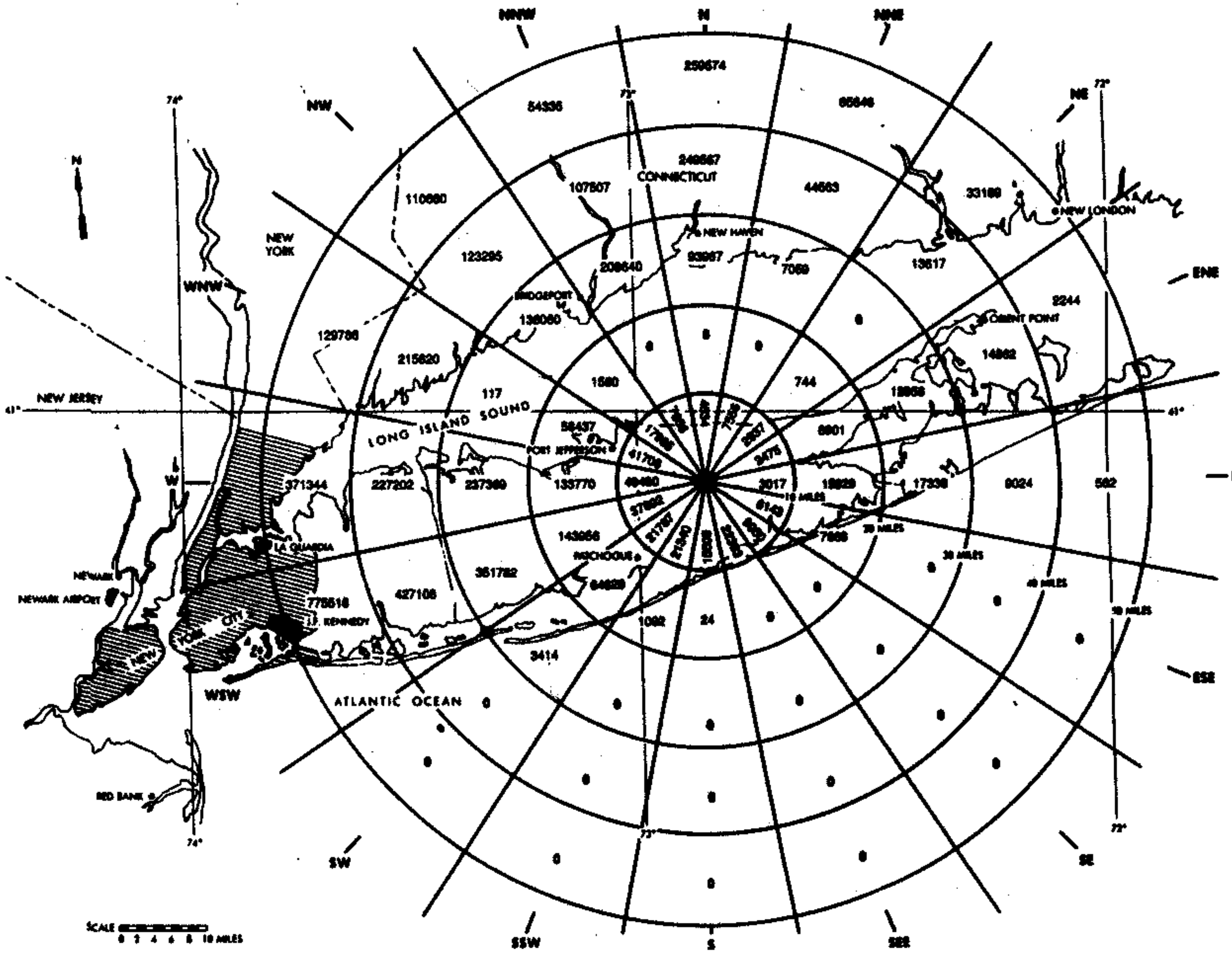

Figure 4-2: RESIDENT POPULATION WITHIN A 50 MILE RADIUS OF BNL

2) The Medical Research Reactor (MRR), an integral part of the Medical Research Center (MRC), is fueled with enriched uranium, moderated, and cooled by light water and is operated intermittently at power levels up to 3 Megawatts (MW) thermal.

3) The AGS is used for high energy physics research and accelerates protons to energies up to 30 GeV and oxygen or silicon beams to 15 GeV/amu.

4) The 200 MeV LINAC serves as a proton injector for the AGS and also supplies a continuous beam of protons for radionuclide production by spallation reactions in the Brookhaven LINAC Isotope Production Facility (BLIP) and in the Chemistry LINAC Irradiation Facility (CLIF).

5) The Tandem Van de Graaff, Vertical Accelerator, Cyclotron, and research Van de Graaff are used in medium energy physics investigations and for special nuclide production. The Tandem Van de Graaff are also used to inject heavy ions into the AGS for use in physics experiments.

6) The National Synchrotron Light Source (NSLS) utilizes a linear accelerator and booster synchrotron as an injection system for two electron storage rings which operate at energies of 750 MeV vacuum ultraviolet (VUV) and 2.5 GeV (x-ray). The synchrotron radiation from the stored electrons is used for VUV spectroscopy and x-ray diffraction studies.

7) The Heavy Ion Transfer tunnel connects the coupled Tandem Van de Graaff and the AGS. The interconnection of these two facilities permits the injection of intermediate mass ions into the AGS where the ions can be accelerated to an energy of 15 GeV/amu. These ions are then extracted and sent to the AGS experimental area for physics research.

8) The Radiation Effects Facility (REF) is being used for proton radiation damage studies on aerospace and satellite components. The REF utilizes the 200 MeV negative hydrogen ion beam produced at the LINAC injector to the AGS.

9) The Neutral Beam Test Facility (NBTF) receives the 200 MeV negative hydrogen beam generated by the LINAC and neutralizes the beam to provide a neutral proton source for use in physics experiments. The facility will be used to study the effect of this type of radiation on aerospace, satellite, and biological targets.

10) The AGS Booster, expected to be commissioned in 1991, is a circular accelerator with a circumference of 200 meters that receives either a proton beam from the LINAC or heavy ions from the Tandem Van de Graaff. The Booster will accelerate proton particles and heavy ions prior to injection into the AGS ring.

Additional programs involving irradiations and/or the use of radionuclides for scientific investigations are carried out at other Laboratory facilities including those of the MRC, Biology Department, Chemistry Department, and Department of Applied Science (DAS). Special purpose radionuclides are developed and processed for general use under the joint auspices of the DAS and Medical Department.

4.2 RHIC Facility Description

The completed RHIC facility would have up to six experimental halls, the Collider Center, Helium Refrigeration Plant, three equipment storage areas, and the Beam Injection Tunnel. Currently, three experimental halls, the Collider Center, equipment storage areas, and the Beam Injection Tunnel exist. Each experimental hall would have a support building and electrical substation associated with it. Existing experimental halls already have support buildings in place. No electrical substations have been constructed to date. Substations would range in size from 2,500 to 3,500 square feet and be rated at 2.5 MVa for all areas except the Beam Injection Tunnel which would be rated at 2.0 MVa. All power, telephone, water, and other utilities would be supplied via underground lines run adjacent to the ring road and access roadways to the experimental facilities. The ring tunnel is placed at grade and covered by earthen shielding which is elevated approximately 30 feet above grade from the ring road. General topography slopes down towards the north giving the appearance that elevations are minimal south of the facility and greater than 30 feet to the north of the facility. Headwaters of the Peconic River enter and exit the ring via culverts in the northwest and east sections of the ring. All wetlands associated with the river within the ring remain undisturbed.

5.0 AFFECTED ENVIRONMENT

This section describes those features of the existing affected environment that are related to the construction and operation of the RHIC. More detailed information concerning the existing environment may be found in the annual environmental monitoring reports for BNL.

5.1 Land Use and Demography

In the past, "Urban sprawl" has been the predominant development trend on Long Island. However, the Nassau-Suffolk Bicounty Master Plan guides future development. This guidance is complemented on the local level by a Brookhaven Town Master Plan. In both of these documents the operation of the Laboratory, and anticipated future projects such as the RHIC, are considered in terms of the projected land use and the population distributions for Long Island.

Suffolk County population has grown from 1.32 million in 1978 to 1.36 million in 1987. This is a three percent increase in the county population, and includes about a four percent increase in the population within 80 kilometers of the Laboratory. Although there has been an increase in residential housing development in the rural area surrounding BNL, there have been no major construction projects in the vicinity since 1978. However, a shopping mall is proposed for a location immediately beyond the site perimeter on the William Floyd Parkway, approximately 4 kilometers from the RHIC.[4]

5.2 Geology and Seismology

Long Island was formed by the terminal moraines of the last two glaciations. Just west of the Laboratory the two moraines are connected by a narrow north/south ridge for which the hamlet of Ridge is named. East of this ridge, and enclosed by it and the two moraines, is the Manorville Basin. The Laboratory grounds are on the Basin's relatively high west margin. Surface deposits vary in texture from place to place. The RHIC site consists of predominantly Carver and Plymouth sands, cut and fill land, Plymouth loamy sand, and Riverhead sand loam with generally less than 10 percent slope. The highest ground of the RHIC site is about 30.5 meters above sea level, and the maximum difference in elevation is about 9.2 meters.

The probable occurrence of an earthquake sufficiently intense to damage buildings and reactor structures in the BNL area was thoroughly investigated during construction of the graphite reactor. It is the consensus of seismologists that no significant quakes are to be expected in the foreseeable future. No earthquake has yet been recorded in the BNL area with an intensity in excess of modified Mercalli III equivalent to 1 to 8 cm/sec^2 acceleration. However, since Long Island lies in a Zone 1 seismic probability area, it has been assumed that an earthquake of intensity VII (e.g., damage negligible of good design and construction) could occur. Liquefaction potential of soils in the RHIC area for such an event is negligible given existing soil density and saturation parameters. Thus, structural stability should remain through an event of this magnitude. No active earthquake-producing faults are known in the Long Island area.[2]

5.3 Hydrology

The general hydrogeology of the region consists of surficial or upper glacial deposits of Pleistocene origin. These deposits range in depth from 20 to 38 meters, lying on the Magothy formation, a unit of stream deposits of Late Cretacean age. The water table height varies from the surface to a depth of 10.3 meters.

The BNL site terrain is gently rolling, with elevations varying between 13.3 and 36.6 meters above sea level. The land lies within the headwaters region of the Peconic River watershed. Wetland areas in the north and eastern section of the site were formerly a principle tributary of the Peconic River. This intermittent tributary was dry from 1984 - 1989, probably a result of regional drought, lowering of the water table, and increased residential land use. Above normal rainfall experienced in 1989 and 1990 has been primarily responsible for continuous flow in the Peconic tributaries from 1989 to the present. A vegetated freshwater wetland corridor follows the river bed inside the existing ring of ISABELLE/CBA. These wetlands are regulated by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act and by the New York State Department of Environmental Conservation (NYSDEC) under Article 24 of the New York Code of Rules and Regulations. A map of wetland habitats found near the ring are shown in Figure 5-1. Liquid effluents from the BNL Sewage Treatment Plant (STP) constitute the only continual source of surface water in the tributary's river bed. Currently, the BNL liquid effluents from the STP recharge to groundwater prior to leaving the site boundary. Treated combined industrial and sanitary

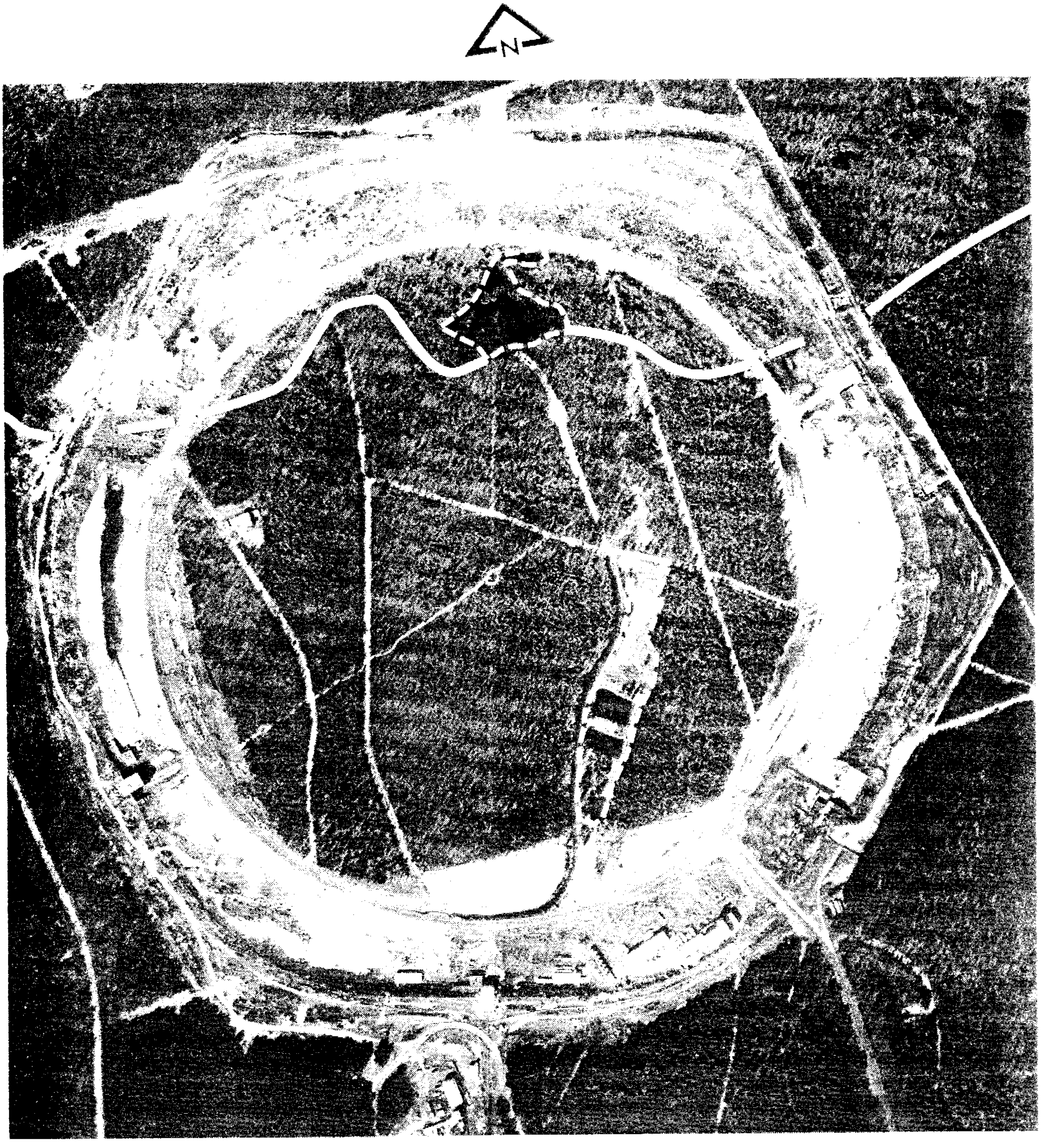

Figure 5-1: Overview of Existing Conditions at the ISABELLE/CBA Showing NYSDEC Regulated Wetlands.

0 1000
feet

wastewater discharged from the STP receives secondary treatment and conforms to criteria in the STP's approved State Pollutant Discharge Elimination System (SPDES) permit issued by NYSDEC.

The aquifer is in dynamic equilibrium and receives precipitation of about 56 centimeters per year, or recharge of about one million gallons per day per square mile. The water table gradient averages about 0.25 meters change over 125 meters, with its height fluctuating 0.5 - 0.75 meters over the last few years. Ground-water flows from north to southeast in the RHIC area at an average rate of 45 centimeters per day.

5.4 Meteorology

The BNL site weather is greatly influenced by the Atlantic Ocean, Long Island Sound, and the many associated coastal estuaries. Their presence moderates both summer and winter temperatures, strongly influences wind and humidity patterns, and greatly reduces the snowfall when compared to that measured at a nearby inland station. The site is well ventilated by winds from all directions with rapid, fairly consistent fluctuations in atmospheric stability. The prevailing ground level winds are from the southwest during the summer, from the northwest in the winter, and about equally from these directions during the spring and fall. The average temperature in 1989 was 10 degrees Celsius and the range was -15 to 40 degrees Celsius. The total precipitation for 1989 was 184 centimeters, which is 62 centimeters above the 39 year annual average.[4]

5.5 Ecology

The Laboratory is located in a section of the Oak/Chestnut forest region of the Coastal Plain. Because of the general topography and porous soil, there is little surface runoff or open water. Upland soils tend to be drained excessively, while depressions form small pocket wetlands. Hence, a mosaic of wet and dry areas on the site are correlated with variations in topography and depth to the water table. In the absence of fire or other disturbance, the vegetation normally follows the moisture gradient closely. In actuality, vegetation onsite is in various stages of succession which reflects the history of disturbances to the area, the most important having been land clearing, fire, flooding, and draining.

Mammals common to the site include species common to mixed hardwood forests and open grassland habitats found onsite. At least 180 species of birds have been observed at BNL, a result of its location within the Atlantic Flyway and the scrub/shrub habitats which offer food and resting opportunities to migratory songbirds. Open fields bordered by hardwood forests found at the recreation complex provide excellent hunting areas for hawks. Pocket wetlands with seasonal standing water provide breeding areas for amphibians. Permanently flooded retention basins and other watercourses support aquatic reptiles.

Common warmwater fish species can be found in the retention basins and flooded palustrine forested and scrub/shrub wetlands enclosed by ISABELLE/CBA. The intermittent nature of the Peconic River headwaters negates the existence of a recreational fishery near the ring area. However, as river surface waters become permanent to the east, a recreational fishery can be found.

Except for occasional transient individuals, no Federal or New York State listed or proposed threatened or endangered species exist within the project impact area (See Appendix). One New York State species of special concern which has been confirmed as an inhabitant downstream of the project area is the banded sunfish (*Enneacanthus obesus*). This species occurs in New York solely within the Peconic River system. That portion of the Peconic River which occurs on BNL property has been designated as "scenic" in accordance with New York State's Wild, Scenic, and Recreational River Act.

The wide variety of wildlife resources at BNL attest to Laboratory planning practices which have clustered development to minimize habitat fragmentation, particularly in environmentally sensitive areas such as the Peconic River corridor. Habitat fragmentation represents the greatest threat to wildlife habitats on Long Island today.

5.6 Baseline Radiological Characteristics

BNL evaluates ambient levels of radioactivity through its environmental monitoring program. Measurements are made of direct exposures as well as activity in air, water, and soil. The following data was obtained from BNL's 1989 Environmental Monitoring Report.

5.6.1 External Radiation Exposure

Thermoluminescent dosimeters are used to monitor the external exposure at onsite and offsite locations. The average annual onsite integrated dose for 1989 was 63.2 plus or minus 7.9 mrem, while the offsite integrated dose was 58.4 plus or minus 7.4 mrem. The difference between the onsite and offsite integrated exposure is within the uncertainty of the measurement and is attributable to the higher terrestrial component of the natural background onsite and not BNL activities. The average integrated dose is within the statistical spread of the measurement. These values are less than ambient dose reported for the New York City area by the Environmental Protection Agency (EPA) for January to December, 1989 which predict an annual dose of about 81 mrem.[4]

5.6.2 Atmospheric Radioactivity

Tritium was the predominant radioactive effluent detected in environmental air samples. The maximum annual average tritium concentration at the site boundary in 1989 was 8.2 pCi/m^3. This concentration would result in a committed effective dose equivalent of 0.0064 mrem to the maximally exposed individual residing at the site boundary for the entire year.[4] Additional emissions of bromine-77, selenium-75, iodine-126, and mercury-203 from Building 801 were detected in May 1989. The effective dose equivalent to the maximum individual resulting from the inhalation of the measured air concentration was 0.016 mrem. This dose is far below the 10 mrem standard set by 40 CFR 61 for the air pathway.

5.6.3 Radioactivity in Precipitation

In rainfall, the following radionuclides were detected: beryllium-7, cesium-137, iodine-131, radium-226, cerium-141, and strontium-90. The measured concentrations were consistent with typical washout values associated with atmospheric scrubbing and are comparable with the 1989 published data by EPA for Yaphank, New York.[4]

5.6.4 Radioactivity in Soil or Vegetation

Offsite soil and vegetation sampling is conducted semiannually as a cooperative effort between BNL and the Suffolk County Department of Health. Radionuclides detected in vegetation and soil in the vicinity of BNL included beryllium-7, potassium-40, cesium-137, radium-226, and thorium-228. Observed concentrations represent the contributions of primordial and cosmogenic sources, and weapons test fallout. No nuclides attributable to Laboratory operations were detected in soil and vegetation samples collected.[4]

In 1989, 22 surface soil samples were collected from onsite locations and analyzed for gamma activity. At the site perimeter and many central site locations, the observed radionuclide concentrations were equivalent to those detected at offsite sample locations.

5.6.5 Collective (Population) Dose Equivalent

The collective (population) dose equivalent (total population dose) beyond the site boundary, within a radius of 80 kilometers, attributed to Laboratory operations during 1989 was 3.2 person-rem and was obtained by the summation of the doses from the liquid and airborne pathway contributions. The data is summarized in Table 5-1.[4]

The collective dose equivalent due to external radiation from natural background to the population within an 80 kilometer radius of BNL amounts to about 300,000 person-rem/yr to which about 97,000 person-rem/yr should be added for internal radioactivity from natural sources.[4]

5.7 Archaeology

Representatives of the New York State Historic Preservation Officer toured BNL on June 27, 1990. The only area of historic and/or archaeological significance identified during this field survey were remnant World War I training trenches located to the southwest of the proposed RHIC site and well outside any proposed construction areas. No disturbance would occur to this historic area. The previous construction completed as part of ISABELLE was authorized by the SHPO as being in compliance with the National Historic Preservation Act and Executive Order 11593. All work for the RHIC would occur on the same footprint as ISABELLE. Based upon this information, the SHPO issued an opinion January 29, 1991 stating the proposed project would have "... No Effect upon cultural resources in or eligible for inclusion in the National Register of Historic Places."[4] This letter is contained in the Appendix.

TABLE 5-1

Brookhaven National Laboratory
Offsite Collective Radiation Dose from all Pathways, 1989

Pathway	DOE Committed Plus Effective Collective Dose person-rem	AIRDOS Collective Dose person-rem	DOE Collective Thyroid Dose person-rem	AIRDOS Collective Thyroid Dose person-rem	DOE Collective Bone Dose person-rem
Air	3.02	2.77	.0048	.0048	NA
Water	.02	NA	NA	NA	NA
Fish	.16	NA	NA	NA	1.78
TOTAL	3.20	2.77	.0048	.0048	1.78

NOTE: DOE collective dose is the result of summing both internal and external measured exposures. AIRDOS collective dose is reported as the measured total body exposure.

5.8 Socioeconomic Baseline

BNL is located in the town of Brookhaven which has the largest population (410,000) of the ten Suffolk towns. Most BNL employees live within the Town of Brookhaven and the economic impact of the Laboratory upon the local area is significant. Since the Laboratory is a basic industry, that is, it derives its income from outside the local region, its health is vital to the general industrial base in the area. The Laboratory employs about 3,200 persons. Laboratory expenditures into the local economy support an estimated additional labor force of about 2,400 persons in related industries and the commercial sector. Moreover, almost 70 percent of all salaries flow into the Brookhaven town economy.

The interaction with educational institutions is particularly strong. In addition to formal courses offered by Laboratory staff in outside schools and colleges and joint research projects between BNL staff and scientists at neighboring universities, employees are active as individuals in the design and improvement of science curricula in the local elementary and secondary schools.[1,3]

6.0 POTENTIAL ENVIRONMENTAL EFFECTS

Potential environmental effects can be assessed for three phases of the RHIC project: construction; operation and decommissioning. Potential effects on the environment during these activities will be minimized through compliance with applicable federal, state, local and BNL policies and regulations. The following sections discuss the applicable regulations and potential impacts associated with each project phase. Discussion will focus on construction and operation impacts only as decommissioning impacts are difficult to accurately define at this early planning stage. Separate documentation in accordance with NEPA would be generated at some future time to detail potential impacts from decommissioning.

6.1 Applicable Environmental, Safety and Health Criteria

Construction and operation of the RHIC would be carried out in compliance with the requirements of numerous applicable laws and regulations. Compliance with applicable requirements will help to minimize or eliminate potential adverse environmental impacts associated with all aspects of the RHIC project.

6.2 Effects from Construction

The RHIC construction would consist of earthwork, concrete pouring, asphalt paving, and assembly of the collider. Potential environmental impacts are discussed below.

6.2.1 Commitment of Resources

A major basis for the proposed use of BNL as the location for the RHIC is the availability of the facilities originally built for ISABELLE/CBA. At present, the conventional structures needed for the proposed RHIC are approximately 90 percent in place. The uncompleted portions of the facility are limited to three research areas which include experimental halls and support structures, utilities and site work. Fossil fuels and water would be used to produce power to operate construction machinery. Construction materials such as wood and metal would be used for infrastructure and system components.

6.2.2 Environmental Impacts

No part of the proposed action would occur in a wetland. However, site work would include such actions as grading, paving, and facility refurbishment which could, if uncontrolled, have an indirect effect on wetlands in the vicinity of the construction (See Figure 5-1). Actions proposed which would occur specifically within the jurisdiction of the NYSDEC would be paving of the inner ring circular road and access roads to tunnel exits, rehabilitating berm areas which have become deteriorated due to erosional forces, and construction to complete the tunnel and any support buildings such as substations or storage areas which could be situated within 100 feet of NYSDEC regulated wetlands. Paving of presently pervious areas to provide improved site access would increase stormwater runoff. Culverts directing flow of the Peconic River under the tunnel areas and the roadway were put into place as part of ISABELLE/CBA construction so no river modifications would be required as part of this action. Berm rehabilitation would be required for berm areas and soils eroded off the berms and resting at the berm toe. Grading activities would disturb topsoil and increase the potential for erosion. Regrading operations directly adjacent to the Peconic River as it flows beneath the berms could cause river bed siltation from erosion of disturbed berm areas. Berm integrity within 100 feet of the Peconic River crossings under the berm is such that no regrading would be required. Erosion control cloth and hay bales would be used to minimize sediment laden runoff from entering the Peconic. Final locations for support buildings have not been determined but it would be possible that a structure could be located within 100 feet of the Peconic River and its associated wetlands. Construction activities would be strictly controlled to minimize vegetative disturbance and control erosion. Erosion control cloth and hay bales would be used to prevent eroded sediments from entering the river. Upon construction completion, disturbed soils would be replanted to ensure an appropriate vegetative filter would be present to control sediment in runoff.

Because of the potential for such indirect wetlands effects, the proposed alterations were reviewed by a representative of the NYSDEC during an August 11, 1990 site visit. Restrictions such as diversion of stormwater runoff to retention basins or non-wetland habitats, immediate mulching and reseeding of disturbed areas, and the use of standard erosion control practices adjacent to wetlands and the river bed would be incorporated into project construction to eliminate potential impacts to these habitats. These environmental protection measures were part of the project proposal submitted to the NYSDEC on August 13, 1991 with a request for authorization to construct in accordance with Article 24 of Environmental Conservation Law (Protection of Freshwater Wetlands). The NYSDEC subsequently issued a Notice of Determination of Non-Significance November 5, 1991. Federal authorization for this project is not required as all work is to be performed outside wetland habitats. The New York District Army Corps of Engineers issued a no jurisdiction determination on September 4, 1991. Through mitigation measures listed above, total avoidance of significant adverse impacts to wetlands and the Peconic River System should be achieved. Should NYSDEC recommend the implementation of additional mitigation measures to further protect and/or enhance environmentally sensitive areas, those measures would also be incorporated into project plans as appropriate.

The Federal Emergency Management Agency's National Flood Insurance Program 100-year floodplain maps of the area indicate the elevation of the 100 year flood in the vicinity of RHIC to be about 52 feet above sea level. The lowest point of construction at RHIC would be at elevation 55 feet above sea level. This puts the entire project above the 100-year floodplain.

The RHIC project would be located within an area designated as "scenic" under the New York State Wild, Scenic and Recreational River Act (WSRRA). The ISABELLE/CBA facilities were constructed prior to the 1987 designation of the portion of the Peconic River flowing through BNL as "scenic". Impacts to the scenic resources of the Peconic River will be minimal. The general public does not have open access to the use and enjoyment of the river located within the BNL boundary. Construction and operation of RHIC will not affect the quality or physical nature of the river, either on the site or downstream. Most of the facilities required for RHIC have been completed and are visible from the Peconic River. Construction of the few remaining facilities will result in minimal additional visual distraction. There will be no impact on the scenic nature of the river itself as a result of RHIC activities. At the RHIC location, the Peconic River is an intermittent stream.

Noise, traffic, and visual effects would be negligible since most of the project will involve manufacture and assembly of the accelerator components, which are done indoors. Visual modifications to the project area should be positive given the plantings that would occur, minimal paving of eroded dirt roads, increased security to eliminate damage from trespassers on dirt bikes, and completion of experimental halls which now exist as large areas of barren sand rutted by various vehicle tracks.

6.2.3 Waste Generation and Management

Construction activities would not generate radioactive wastes. Solvents and oils used for cleaning and lubricating would be kept in approved containers meeting the requirements of Suffolk County Article 7. Contractor operations involving these and other chemicals, such as soaps and paints, would be administratively controlled to ensure that wastes generated from these materials are handled and disposed of properly. Waste generation from construction is expected to be minimal.

The manufacture of superconducting magnets requires a special epoxy resin-impregnated material that is compatible with cryogenic temperatures. Some emissions would occur during magnet curing and vapor degreasing, but these would be of small quantities over a limited time frame and in compliance with existing NYSDEC permit authorizations. Current BNL operations of the vapor degreasing unit are permitted under NYSDEC Permit Number 472200349190501 issued March 23, 1990. This permit authorizes the emission of 1,115 pounds per year of trichloroethane. Current magnet fabrication activities for offsite projects are expected to wind down as RHIC magnet fabrication commences. Magnet curing could release trace amounts of aliphatic amine, bisphenol A epoxy resin, fiber resin, bisphenol A diglycidyl ether resin, methyl ethyl ketone, antimony trioxide, and diuron. Decomposition products include carbon dioxide, carbon monoxide, aldehydes, hydrochloric acid, and nitrogen oxide compounds. All emissions would occur within existing buildings. Based upon charcoal tube sampling done in active magnet curing areas, no compounds were found above the detection limit of 20 ug/L. Given this information, no ventilation of air releases to the outdoors would be required and no specialized protection to workers would be necessary. Oil misting would not be a problem because the existing BNL magnet curing operations have been recently upgraded so oil misting occurs in a closed system permitting no external emissions. Other assembly operations, such as machining and welding, would result in wastes common to ordinary assembly and construction activities.

6.2.4 Socioeconomic Effects

The RHIC construction activities are projected to take place from 1991 - 1996, with a total budget of about $397 million. Approximately $70 million is designated for salaries of Brookhaven personnel (1,300 person-years), with another $5.3 million slated for conventional construction. The remainder of the budget will be expended on materials and services supplied by offsite vendors.

These expenditures will carry significant benefits for the neighboring communities. Experience from other projects indicates an implicit project income multiplier of 1.48. With about 25 percent of the materials being obtained in the local areas, the combination of salaries and materials will provide an injection of approximately $250 million into the local economy.

6.3 Effects from Operation

6.3.1 Commitment of Resources

All fresh water available to BNL and surrounding communities comes from an EPA designated sole source aquifer. Protection of this critical element requires scrutiny of all operational programs on water consumption and potential contamination. Water consumption at the RHIC would be minimized through the use of a closed-cycle heat removal system. It is estimated that the total demand of the RHIC (in addition to current BNL usage at all existing/proposed facilities) would require 450 gallons per minute (GPM) for cooling purposes, of which approximately 150 GPM would be consumed as make-up for evaporation losses.[6] This would represent a total increase in BNL pumpage of 12% and an actual increase in water usage of 4%, a small increment of total Laboratory use, which is about 4,500 gpm withdrawn and 2,250 gpm returned through recharge basins. This water would be drawn from process well supplies which are generated by up to seven wells depending on operational constraints. As each operational well would be providing supply toward this increase, the production increase of each well would be very small and would produce imperceptible modifications to existing drawdown cones in well capture zones. Using the Water Table Balance for BNL provided in the Appendix, RHIC's actual requirements of 144,000 gallons per day (GPD) represent only 3% of the Margin of Safe Yield volume of 5,200,000 GPD available to BNL. This increase would also be about the same as past operating conditions which have decreased 10% since 1985 as a result of the implementation of various water conservation activities by BNL. Pumpage required by this project is well within permitted pumpage volumes for BNL supply wells.

The RHIC is projected to require 27.7 MW of electrical power, with the injector system (AGS, Booster, LINAC, etc.) using another 16.8 MW strictly for accelerating ions that would be injected into the RHIC. The Laboratory's present peak electrical demand is 40 MW. Thus, the RHIC could result in an increase of 70 percent to the total BNL peak load. The extra load due to the RHIC would be essentially constant, with slow variation at times of shutdown and start up. Power is now supplied to BNL by the New York Power Authority (NYPA) from electricity generated at the Fitzpatrick Nuclear Power Plant located near Oswego, New York. Approximately 84% of BNL's energy demands are met by NYPA and the additional 16% is met by the Long Island Lighting Company. The NYPA has indicated that the Fitzpatrick plant has 75,000 kW available for industrial customers and would seriously consider a request for additional allocation from BNL. No additional construction would be required offsite to meet the additional energy demands created by the RHIC. Nine substations would be constructed at various locations of the RHIC to facilitate power distribution to the various operational and experimental programs associated with the facility.

The other major use of energy would be the burning of fossil fuels at the BNL central steam plant. Present estimates project a three percent increase in steam production to meet the RHIC heating and air conditioning requirements. This increase would be within the plant's reserve capacity.

6.3.2 Environmental Impacts

As previously stated, BNL water usage does not have an appreciable impact on ground water. With the small increase in water demand that would be created by the RHIC, no changes to surface water resources would be anticipated, therefore no wetlands or other environmentally sensitive areas would be impacted. Currently, water utilized by BNL which is not lost to evaporation is discharged either to the sanitary system or one of five on site recharge basins. Sanitary and industrial wastewater discharged to the sanitary system is treated at BNL's STP before finally being discharged to the Peconic River. Input from the STP to the Peconic suffices to keep a constant flow in the river from this point downstream. Discharges to the Peconic River and the recharge areas must conform to conditions of BNL's SPDES permit issued by NYSDEC. The RHIC is not expected to produce discharges above permissible limits given that the STP is currently operating at 60% of its authorized capacity of 1.8 millon gallons per day and no limit exists for the recharge basins. Other than domestic sewage, expected to be about 12,000 GPD, most water utilized by the RHIC would be as non-contact cooling water and would be discharged to recharge basins. All recharge basins are monitored for contaminants and must also meet the conditions of the SPDES permit.

An increase in the use of fossil fuels at the Laboratory's central steam plant would increase plant air emissions. Boilers at the plant meet all air emissions criteria under existing air permits. As plant facilities are upgraded to replace antiquated equipment, air emissions will be reduced below present levels. The three percent increase in output that would be required from the steam plant for the RHIC can be accommodated by the existing facility without facility expansion. Given all required air emission limits would be met no significant impacts to air quality would be anticipated.

6.3.3 Waste Generation and Management

During RHIC operations, some beam line components could become activated. If any of these components fail, they would be removed from service and placed in indoor, shielded holding areas subject to controlled access. After allowing for decay of short-lived radioisotopes, the items would then be moved to the Hazardous Waste Management Facility (HWMF) on the Laboratory site for secure storage and eventual packaging and shipment offsite as low level radioactive waste. Other hazardous or radioactive wastes generated during operations, such as from maintenance, would be handled in a similar manner.

BNL's HWMF is scheduled for modification and upgrade to meet regulatory standards. The HWMF upgrade project will increase the storage and handling capacity of the HWMF and rehabilitate the complex to satisfy safety and environmental concerns. The major focus of the upgrade is the provision of a new 80 foot by 80 foot high-bay building to facilitate handling and interim storage of large components. Furthermore, increased appropriation of waste management funds will facilitate the prompt offsite disposal of radioactive and/or hazardous waste.

Besides the packaging of wastes for disposal, BNL has also instituted an aggressive waste minimization program directed toward reduction of hazardous waste generation by substituting non-hazardous solvents/materials for hazardous materials where appropriate and maximizing the use of certain items like oily rags. Operation of the RHIC will be in compliance with the waste minimization program. Wastes expected to be generated during operation of the RHIC would be disposed of as follows:

- Solid waste which is non-hazardous and non-radioactive would be disposed of through the services of an offsite vendor. Currently, the Laboratory generates about 1,500 tons of solid waste annually. Solid waste generated by RHIC would result in an increase of 75 tons of solid waste per year.

- Hazardous non-radioactive waste would be disposed of via the services of a group of firms presently under contract to BNL. Disposal services are typically comprised of incineration, landfilling and/or resource recovery, depending on the particular waste stream involved. These operations are performed at various permitted facilities around the United States. Approximately 45 tons of hazardous wastes were generated by BNL in 1989. It is expected that contributions from the RHIC would add one ton per year to this total.[11]

- Low level radioactive waste would be shipped to and disposed of through burial at the Hanford site in the State of Washington. Initial handling and packaging of the waste would be accomplished at the HWMF. Radioactive waste generated at BNL in 1989 totaled 7,308 cubic feet. Operations of the RHIC would be expected to add 300 cubic feet annually to this volume.[11]

Depending on experimental operations, some components of the waste stream at the RHIC could be increased to 20% of current BNL waste generation. The HWMF at BNL currently operates on an interim status under 40 CFR Part 265. On-site storage of hazardous and mixed waste is limited to 320 fifty-five gallon drums given adequate secondary containment. No limitation is imposed on storage of radioactive wastes. Hazardous waste storage is further limited as follows: 80 drums of flammable waste; 80 drums of acid waste; 80 drums of bases and solvents; and 80 drums of oil wastes.

Water use in the RHIC facility would be in two streams: process use (cooling tower make-up) and domestic use. Process use is divided into evaporative losses and blow down to control solids buildup. As there would be no chemical treatment of cooling tower water other than intermittent shock treatment, and since blow down would be returned at approximately ambient temperature, the recharge of this water stream should have only minimal influence on the underlying aquifers. In those cases when intermittent shock treatment is performed on the cooling tower system for the purposes of controlling algae growth, corrosion, and precipitated deposits, the corresponding effluents would be carefully monitored before release to insure compliance with BNL's SPDES permit. It is anticipated that the chemicals used for this purpose would be similar to those presently in use at the

Laboratory in other cooling tower systems which have been selected and are used in accordance with NYSDEC regulations so as to cause minimal environmental impact.

The domestic water used in the RHIC facility, approximately 50,000 liters per day, would be discharged to the Laboratory sanitary system and ultimately to the STP. Since accelerator operations are relatively clean and no deleterious chemicals are expected to be used, the only anticipated contaminant in this discharge would be sanitary and industrial waste. Given the STP is currently operating at only 60% of its authorized capacity of 1.8 MPD, increases associated with the RHIC operations would be easily accommodated.[2]

6.3.4 Radiological Effects

The radiological effects from both normal and abnormal operation of the RHIC are discussed in the following section. Anticipated effects due to operation of the RHIC should be minimal because of the inherently clean operating characteristics of accelerators using superconducting magnets.

6.3.4.1 Normal Operation

Normal operation of the RHIC could include one of several circumstances: full facility power with no beam injection; start-up and testing without the beam (magnets cold and powered); scheduled shutdown for routine maintenance; routine maintenance with power; and helium plant power only. Only normal operation of the RHIC with beam injection would result in activation of air and soil as well as the production of external, penetrating radiation fields. The maximally exposed offsite individual could receive an incremental annual dose of 0.75 mrem due to normal RHIC operations (0.45 from skyshine, 0.3 from muons). Recharge basin discharges would consist of secondary contact water only. Incremental annual dose calculations have been done assuming operation at the ultimate capability of the machine, which could result in conservatism by as much as a factor of four in determining activation and direct exposure. These values are based on a maximum RHIC energy of 100 GeV/amu, with the equivalent of 8.6×10^{14} Au ions accelerated per year. For a proton beam, under the same fault conditions, the doses reported above and below would approximately double. This value is far below the 100 mrem exposure limit set by DOE orders. For detailed information on the doses provided below refer to the RHIC Preliminary Safety Analysis Report.

6.3.4.1.1 Direct Radiation

Although the laboratory site is considered to be a limited access facility, service personnel from offsite and BNL non-radiation workers may work or visit near the RHIC. Laboratory policy for such personnel is to restrict the annual dose to less than 25 mrem/yr. This goal would be accomplished through shielding design that would reduce the RHIC's average contribution to the dose rate outside the RHIC areas of transient occupancy to less than 0.5 mrem/hr.

During normal operation, the maximum onsite dose rate from direct radiation would be 36 mrem/hr. This would occur on the berm near the dump location during a beam dump. As with all regions greater than 5.0 mrem/hr or 100 mrem/yr, this region would be posted and controlled as a radiation area where appropriate. Worker entrance to the berm area would only occur during maintenance operations so no unnecessary exposures would occur. During injection, the one half percent loss assumption yields a dose rate of 0.025 mrem/hr in the injection area.

The Collider Center (Building 1005) is specifically addressed due to the building's proximity to the ring and beam dump, and the presence of non-radiation worker personnel in the building. Personnel in the Center would be exposed to direct beam and skyshine radiation due to routine losses. Direct doses would be about 2.0 mrem/yr, while skyshine from the dump and two Limiting Aperture Collimators (LACs) would be approximately 6.0 mrem/yr. Total dose at the Collider Center due to routine losses would thus be about 8.0 mrem/yr, still well below the 100 mrem/yr limit.

Routine losses would be expected to contribute less than 0.6 mrem/yr to the offsite dose from interactions at the internal beam dump and less than 2.0 mrem/yr due to the LACs. Half of this dose would be from skyshine and half from muons which penetrate the shielding.[8] This contribution is well below the authorized limit of 100 mrem/yr.

6.3.4.1.2 Soil Activation and Groundwater Effects

Secondary particles created by beam interactions would escape into the soil surrounding the tunnel on all sides. Some of the particles would interact with the silicon and oxygen atoms present in the soil. Radionuclides typically created by these processes are tritium, beryllium-7, carbon-11, nitrogen-13, oxygen-15 and sodium-22. Once present in the soil they could be leached downward to the groundwater by rain and then transported by the groundwater to wells both onsite and offsite. These processes are quite slow and therefore only the longer lived tritium and sodium-22, of which less than 11 mCi and 14 mCi respectively, are produced each year, would contribute to potential human exposure.[9] This release would produce an exposure through water pathways several orders of magnitude below Safe Drinking Water Act standards of 4 mrem per year.

The current maximum offsite dose to an individual resulting from the ingestion of tritium contaminated ground water is about 0.07 mrem per year, assuming 100 percent consumption of contaminated water and International Commission on Radiological Protection Report #30 dose conversion factors.[4]

The RHIC would be expected to add less than 0.001 mrem/yr as a result of tritium contamination of the ground water and 0.001 mrem/yr from sodium-22. Although other radionuclides are produced in soil activation, the rate of leaching, retardation factors, and the transit time offsite is sufficiently long to allow for decay of these materials to levels inconsequential to dose estimations and not detectable by state-of-the-art assay methods. Consumption of contaminated water from Well #11 would be expected to add 0.14 mrem to individual onsite doses if this were the only source of drinking water, also well below the 4 mrem per year standard.

6.3.4.1.3 Emission of Airborne Radioactivity

The RHIC would be expected to produce the following air activation products: tritium; beryllium-7; nitrogen-13; carbon-14; oxygen-14; oxygen-15; sodium-22; aluminum-28; phosphorous-32 and argon-41. The production rates of these radionuclides plus the estimated quantities released to the atmosphere are summarized in Table 6-1. The difference between the production rates and release rates would be a result of decay between the time of creation in the RHIC sextant tunnel and release.

TABLE 6-1

Projected Air Activation and Release Due to RHIC Operation

Nuclide	Half-Life	Equilibrium Production Ci/year	Estimated Release Rate Ci/year
Tritium	12.3 yr	1.3E-4	1.3E-4
Beryllium-7	53.3 d	3.3E-3	3.3E-3
Carbon-11	20.4 min	1.3E+1	6.1E+0
Nitrogen-13	9.9 min	2.9E+1	8.9E+0
Oxygen-14	71.0 sec	5.6E+0	2.8E-1
Oxygen-15	122.0 sec	1.2E+2	9.4E+0
Sodium-22	2.6 yr	1.1E-6	1.1E-6
Aluminum-28	2.3 min	6.7E-1	6.2E-2
Phosphorous-32	14.3 d	2.0E-4	2.0E-4
Argon-41	1.8 hr	4.1E-1	3.4E-1

RHIC Energy = 100 Gev/a
Au Ions accelerated per year 8.6 x 10^{14}

Several conservative assumptions were made to make these estimates of annual releases. First, 100 percent of the tunnel air would be exhausted. The planned operational mode would be to recirculate as much building air as possible. Second, all the activity would be assumed to be generated and released from the sextant that is closest (250 meters) to the offsite population. Finally, the upgraded beam intensities would be used to generate estimates of air activation.

The maximum dose to an individual resident at the site boundary as a result of the estimated releases in Table 6-1 from the RHIC operation would be expected to be 0.016 mrem. The collective dose is expected to be 6 person-mrem.

The collective dose from all airborne effluent releases at BNL in 1987 was 2.4 person-rem. The maximum site boundary dose was 0.064 mrem. The estimated dosimetric impact of operating the AGS Booster was estimated to be 0.02 mrem at the site boundary and 9 person-mrem for the collective dose. The total dosimetric impact due to air emissions from operating the RHIC, Booster and all other facilities would be a maximum 0.1 mrem to an individual at the site boundary and a collective dose of 2.4 person-rem.[10]

6.3.4.2 Abnormal Operation

Three potential dose pathways: air; water; and direct radiation, have been analyzed for abnormal operation/incident scenarios. The most extreme abnormal event that could potentially occur would result in a one time loss of the entire beam at a single point. The chance of such an event occurring is estimated to be once every three to four years. This is based on the operating histories of two similar superconducting colliders in existence, the Large Hadron Collider at the Center for European Nuclear Energy Research (CERN) in Switzerland and the Tevetron at Fermilab in the United States. Should the beam be lost in this manner it would produce a 34 mrem dose at the top of the berm. Such a beam loss would produce an off-site dose rate of approximately 0.009 mrem/event due to skyshine. In the Collider Center, the dose rate from direct beam radiation would be about 0.65 mrem/event, with another 0.09 mrem/event from skyshine. This would give a total dose rate in the Collider Center of 0.74 mrem/event due to this incident. Given these doses, the RHIC facility would be classified as a "Low Hazard" in accordance with DOE Order 5481.1B, Chapter 3(a)1. This designation means that hazards associated with the facility under all conditions present minor onsite and negligible offsite impacts to people or the environment. No off site emergency planning is required at a facility such as the RHIC which would result in such minor impact.

There is no identifiable incident that could impact the water pathway. Soil activation and subsequent leaching has been conservatively estimated under normal conditions by overstating the operating characteristics of the machine. These conservative measurements fall well below the Safe Drinking Water Act standards of 4 mrem per year.

For air emissions (see 6.3.4.1), several conservative estimates were made to calculate "normal" emissions. By assuming complete tunnel exhaust, minimum transit time offsite and maximum isotope production, 0.016 mrem would be the effective limit of off-site dose impacts due to abnormal operation. Consideration was also given to the fact that RHIC would be capable of melting a portion of the vacuum beam line, thus vaporizing some amount of activated material. However, this would not result in releases to the atmosphere. Therefore, events from abnormal operations are within the calculations done for the air pathway. This value of 0.016 mrem is over 600 times less than the regulated annual release permitted of 10 mrem.

6.3.4.3 Summation of Health Effects

Using the information provided in 6.3.4.1 and 6.3.4.2, health effects resulting from RHIC operations were estimated. Estimates were prepared using the recommendations in Report 60 prepared by the International Commission on Radiological Protection (ICRP).[13] This report uses the most recent risk estimates in the Biological Effects from Ionizing Radiations Report (BEIR-V) issued by the National Academy of Sciences (NAS).[14] Assumptions used in the estimate were: a member of the general public resides on the site boundary closest to RHIC, 24 hours a day, 365 days a year; occupancy is continuous for the projected 20 year life of the machine; and in addition to radiation dose from normal operation, five abnormal incidents as described in Section 6.3.4.2 would occur. As mentioned previously the frequency of abnormal events was estimated using the operating histories of other similar colliding beam accelerators. Calculations determine that the total radiation dose to this individual over a 20 year period would be 15.4 mrem from normal operations and 0.05 mrem from abnormal operations, totaling 15.45 mrem. This dose represents 0.77% of the dose natural background radiation would cause over the same period. Using the ICRP and NAS methods of risk prediction, the additional risk of a person residing at the site boundary to contract a fatal cancer would be 1 chance in 100,000 or 0.001%. Realistically, given this information no radiation health effects are expected to occur.

6.3.5 Socioeconomic Effects

The operation of the RHIC at BNL would result in an increase of about 200 permanent staff positions, with a corresponding increment of $16.8 million in salaries and benefits. Overall, RHIC operations, including the Injector System, would be estimated to cost $54 million annually. As this money would enter the local economy, the overall impact from RHIC related expenses could reach $85 million including $40 million from the total labor costs. The associated influx of new people would further enhance BNL's strong impact on the social and cultural well-being of the local area since there is a strong interaction between BNL and regional academia as well as industry.

6.4 Decontamination and Decommissioning

The following sections discuss the impacts of decontamination and decommissioning the RHIC facility on waste generation and for future uses at the site.

6.4.1 Quantity of Induced Radioactive Waste and Construction Debris

The nature of particle acceleration operation in the RHIC would be such that the magnitude of induced radioactivity is small and would occur in only a few specific components, such as beam dumps, internal absorbers and scrapers, inflectors, system magnets and some vacuum equipment. These components would be categorized as low-level waste and would be shipped for disposal offsite at existing federal facilities. The extractor septum magnet would be activated to somewhat higher levels, but these would decay to low levels in a short time span (weeks). Estimates of the amount of low level radioactive waste that would require disposal, assuming no components would be reusable, would amount to approximately 173,000 cubic feet. Construction debris from dismantling would include 50,000 cubic yards of concrete, 200 tons of steel, 1,500 tons of the multiplate arch tunnel, and 50 tons of miscellaneous materials. To access the multiplate arch would require the excavation of 750,000 cubic yards of earthen shielding which would be stockpiled and regraded following tunnel and component removal.

The beam dump could localize significant beam losses to a single location which would be provided for by the use of extra internal shielding. The surrounding soil would become activated to some degree, primarily with tritium. Therefore, some level of remediation would need to be considered at the time of decommissioning.

Doses during maintenance or decommissioning would be expected to be low since only a limited number of RHIC components would have been significantly activated. Detailed discussion of decommissioning would be reserved for a separate NEPA document to be prepared near decommissioning when detailed data would be available.

6.4.2 System Design Considerations

Successful operation of a superconducting accelerator inherently minimizes induced radioactivity because of the necessity for clean runs and fine beam control. This aspect of the RHIC machine would be accentuated by using marble for shielding near the beam dump, a material which becomes less activated than more common shielding materials thereby minimizing radioactive waste generated at decommissioning. Careful assembly records would be kept to aid in systematic dismantling of the machine at the end of its useful life. BNL has developed a policy regarding retention of records and other information consistent with the requirements of DOE Order 5820.2.

7.0 SUMMARY OF IMPACTS INCLUDING CUMULATIVE RHIC/BNL TOTAL OPERATION

The potential environmental impacts due to construction and operating the RHIC have been analyzed. The following summary of information addresses the impacts of construction and operation of the RHIC machine cumulative with existing and the reasonably foreseeable operations at BNL. Detailed discussion of decommissioning would be reserved for a separate NEPA document to be prepared near decommissioning when detailed data would be available.

Because the RHIC would utilize the facilities previously constructed for ISABELLE/CBA and other facilities at BNL, little additional construction would be required and there would be very little disturbance of previously undeveloped land. Production of machine components such as superconducting magnets has resulted in some emissions of epoxy resin from curing units. However, these emissions, which are well within NYSDEC authorized limits, would not be expected to increase as a result of superconducting magnet production for ISABELLE/CBA. Degreasing operations would be conducted in compliance with existing NYSDEC permit authorizations. Construction activities would not generate radioactive wastes.

RHIC operations would increase the base BNL electric power requirements by about 20 MW due to refrigeration and other utilities. A further 8 MW would be needed for transient loads. This 28 MW load increment can be handled by the current power distribution system of the NYPA which now provides 84% of BNL's power. A request for additional power allocation by BNL to NYPA would receive serious consideration.

There would be four sources of radiological impacts during RHIC operation: direct radiation; skyshine; releases of activated air from the tunnel and releases of radionuclides to the groundwater. At the site boundary these doses would be 0.3 mrem/yr, 0.45 mrem/yr, 0.016 mrem/yr, and 0.002 mrem/yr, respectively, totalling

0.77 mrem/yr. This compares to the current value of 1.1 mrem/yr from BNL releases. Combined existing and RHIC associated releases would still be 50 times lower than DOE permitted limits. Areas adjacent to the RHIC where there exists a potential to receive doses in excess of 25 mrem/yr from normal operation would be fenced and/or posted, as appropriate. The additional risk of a fatal cancer due to RHIC operation would be 0.001%.

RHIC operations would result in less than a five percent increase in the amount of solid waste generated, less than three percent of the hazardous non-radioactive wastes generated and less than five percent of the radioactive waste generated from all BNL projects. These increases would not considered significant and combined with waste minimization and recycling practices should produce insignificant environmental impacts. Current BNL vendor agreements would continue to permit BNL to meet Interim Operating Status requirements in accordance with NYSDEC Hazardous Waste Regulations.

8.0 REFERENCES

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9.0 LIST OF AGENCIES CONTACTED

New York State Department of
Environmental Conservation
Stony Brook, New York

New York Natural Heritage Program
Delmar, New York

New York State Historic
Preservation Office
Albany, New York

Suffolk County Department
of Health Services
Hauppauge, New York

U.S. Army Corps of Engineers
New York, New York

U.S. Department of Energy
Chicago, Illinois

U.S. Department of Energy
Upton, New York

U.S. Environmental Protection Agency
New York, New York

U.S. Fish and Wildlife Service
Cortland, New York

U.S. Geological Survey
Syosset, New York

10. APPENDIX

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
100 Grange Place
Room 202
Cortland, New York 13045

cc: Tom Sperry
9/28

September 25, 1990

Mr. Gerald C. Kinne
Associate Director
Brookhaven National Laboratory
Upton, Long Island, New York 11973

Attn: Mr. Tom Sperry
Laboratory NEPA Coordinator

Dear Mr. Kinne:

This responds to your letter of September 6, 1990 requesting information on the presence of Federally listed or proposed endangered or threatened species in the vicinity of the Relativistic Heavy Ion Collider construction project at your facility located at Upton, Suffolk County, New York.

Except for occasional transient individuals, no Federally listed or proposed endangered or threatened species under our jurisdiction are known to exist in the project impact area. Therefore, no Biological Assessment or further Section 7 consultation under the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.) is required with the Fish and Wildlife Service (Service). Should project plans change, or if additional information on listed or proposed species becomes available, this determination may be reconsidered.

This response relates only to endangered species under our jurisdiction. It does not preclude additional Service comments under the Fish and Wildlife Coordination Act or other legislation.

Please contact us if we can be of further assistance.

Sincerely,

Leonard P. Corin
Field Supervisor

New York State Department of Environmental Conservation
Building 40—SUNY, Stony Brook, New York 11790-2356

(516) 751-7900 EXT.248

SEP 28 1990

Thomas C. Jorling
Commissioner

Gerald C. Kinne
Brookhaven National Laboratory
Upton, Long Island, NY 11973

September 24,1990

Re: Construction of a Relativistic Heavy Ion Collider at Brookhaven National Laboratory facility, Upton, Suffolk County, NY.

Dear Mr. Kinne;

We have reviewed the Significant Habitat Program and Natural Heritage Program files with respect to your request of 09/06/90 regarding the above referenced properties.

We did not identify any potential impacts on endangered, threatened, or special concern wildlife species, rare plant, animal or natural community occurrences, or other significant habitats.

The absence of data does not necessarily mean that rare or endangered elements, natural communities or other significant habitats do not exist on or adjacent to the proposed site, but rather that our files currently do not contain any information which indicates the presence of these. Our files are continually growing as new habitats and occurrences of rare species and communities are discovered. In most cases, site-specific or comprehensive surveys for plant and animal occurrences have not been conducted. For these reasons, we cannot provide a definitive statement on the presence or absence of species, habitats or communities. This information should not be substituted for on-site surveys that may be required for environmental assessment.

If this proposed project is still active one year from now we recommend that you contact us again so that we can update this response.

If we can be of further assistance please do not hesitate to contact us.

Sincerely,

Michael S. Scheibel

Michael S. Scheibel
Senior Wildlife Biologist

NODATA.DOC

OFFICE OF PARKS, RECREATION, HISTORIC PRESERVATION
STATE
ehman
Commissioner

New York State Office of Parks, Recreation and Historic Preservation
The Governor Nelson A. Rockefeller Empire State Plaza
Agency Building 1, Albany, New York 12238-0001

January 29, 1991

Ms. Jane L. Monhart
Acting Area Manager
Department of Energy
Brookhaven Area Office
Upton, New York 11973

Dear Ms. Monhart:

Re: DOE
Relativistic Heavy Ion Collider
Brookhaven National Laboratory
Brookhaven, Suffolk County
91PR0065

Thank you for requesting the comments of the State Historic Preservation Office (SHPO). We have reviewed the project in accordance with Section 106 of the National Historic Preservation Act of 1966 and the relevant implementing regulations.

As you may be aware, our office is in the process of developing a memorandum of understanding regarding potential projects at the Brookhaven National Laboratory. Construction of the RHIC facility is outside the area of the laboratory campus that is of concern to the SHPO. Consequently, based upon our review of the project, it is the SHPO's opinion that it will have No Effect upon cultural resources in or eligible for inclusion in the National Register of Historic Places.

If you have any questions, please call Tony Opalka of our Project Review Unit at (518) 474-0479.

Sincerely yours,

Julia S. Stokes
Deputy Commissioner for
Historic Preservation

JSS/TO:tr

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WATER BALANCE

SAFE YIELD vs PUMPAGE

•TOTAL LABORATORY AREA	2.3 E8 SQ.FT.
•PAVED AREA - NOT AVAILABLE FOR RECHARGE	3.2 E6 SQ.FT.
•FOOTPRINT OF BUILDINGS - NOT AVAILABLE FOR RECHARGE	2.5 E6 SQ.FT.
•TOTAL AREA AVAILABLE FOR RECHARGE	2.2 E8 SQ.FT. or 8.0 SQ.MILES
•VOLUME OF WATER RECHARGED BY RAINFALL AT THE RATE OF 1.12 MILLION GALLONS/SQ.MILE	9.0 E6 GPD
•PERMISSIVE SUSTAINED YIELD EQUALS 75% OF TOTAL RECHARGE	6.8 E6 GPD
•BNL PUMPAGE(1989)	5.4 E6 GPD
•VOLUME RECHARGED BY BNL(1989)	3.8 E6 GPD
•NET PUMPAGE(1989)	1.6 E6 GPD
•MARGIN OF SAFETY OR SAFE YIELD	5.2 E6 GPD

FINDING OF NO SIGNIFICANT IMPACT

RELATIVISTIC HEAVY ION COLLIDER

at the

BROOKHAVEN NATIONAL LABORATORY, UPTON, NY

AGENCY: Department of Energy

ACTION: Finding of No Significant Impact

SUMMARY: The Department of Energy (DOE) has prepared an Environmental Assessment (EA), DOE/EA-0508, of the proposed action to construct and operate the Relativistic Heavy Ion Collider (RHIC) at the Brookhaven National Laboratory (BNL), Upton, New York. The RHIC facility would provide an ability to collide heavy ions of over ten times the beam energy generated by colliding heavy ions at any existing or proposed facility in the world. The project would utilize the existing facilities previously constructed for the ISABELLE/Colliding Beam Accelerator (CBA) at BNL plus other needed equipment, facilities, and components. Remaining construction, specific to permit the operation of the RHIC, would consist of completion of the tunnel, building three experimental halls with support facilities, such as substations, storage space, paving the road, fabricating and installing superconducting magnets and associated accelerator systems, rehabilitating existing berms, and instituting a planting program to control berm erosion and provide shading to the Peconic River. Based on the information and analyses in the EA, DOE believes that the proposed action is not a major Federal action significantly affecting the quality of the

human environment within the meaning of the National Environmental Policy Act (NEPA) of 1969. Therefore, the preparation of an Environmental Impact Statement is not required and DOE is issuing this Finding of No Significant Impact (FONSI).

ADDRESSES AND FURTHER INFORMATION: Persons requesting additional information regarding the RHIC project or wishing a copy of the EA should contact:

David Goodwin
U.S. Department of Energy
Brookhaven Area Office
Upton, NY 11973
(516) 282-3424

For general information on the NEPA process, please contact:

Carol Borgstrom, Director
Office of NEPA Oversight
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 586-4600

SUPPLEMENTARY INFORMATION:

Background: In 1983, the concept of a heavy ion collider facility, reaching center-of-mass collision energies at least ten times higher than maximum collision energies obtainable at existing accelerator facilities, was identified as the highest priority need for a new facility in the Long Range Plan for basic nuclear research in the U.S. Immediately thereafter, a panel was formed, which included leading experimentalists and theorists from both high energy and nuclear physics throughout the U.S. and in Europe, to consider the basic design requirements for such a facility. This group formulated the essential design parameters for a relativistic heavy ion collider which would incorporate the flexibility to study collisions of all nuclei from the lightest to the heaviest and allow experiments to be carried out over the full range of energies. The technical parameters were developed for an accelerator complex which would utilize the facilities already in place from the ISABELLE/CBA project at BNL.

The proposed action consists of the construction and operation at BNL of the RHIC facility to provide a unique heavy ion research facility which would extend by at least an order of magnitude the center-of-mass collision energies available with man-made beams of nuclei. The RHIC would utilize existing (though unfinished) facilities already in place for the ISABELLE/CBA at BNL, plus other needed equipment, facilities, and components existing at BNL including a Tandem Van de Graaff Accelerator, Heavy Ion Transfer Line (HITL), Alternating Gradient Synchrotron (AGS), and AGS Booster. All of the facilities are currently operating except the AGS Booster. The Tandem Van de Graaff accelerator would serve for the initial ion acceleration. From this point, the ions would traverse the long (approximately 610 meters) Heavy Ion Transfer Line (HITL) to allow injection into the Booster accelerator. After extraction from the Booster, the ions would enter the Alternating Gradient Synchrotron (AGS) where they would be accelerated to the top AGS energy (28 GeV/amu for gold). The particles would be transferred to the collider by a magnet system installed in the existing transfer line tunnels. Superconducting magnets would bend and focus the ion beams within the RHIC. The entire system is designed with incorporated safety measures which would automatically shut down machine operation in response to any event that would lead to uncontrolled beam loss.

Construction of the ISABELLE/CBA commenced in 1979, and continued until 1983, when support was withdrawn from the project. Remaining construction, specific to permit the operation of the RHIC, would consist of building two experimental halls with support facilities, such as substations, storage space, paving the ring road, fabricating and installing superconducting magnets and associated accelerator systems, rehabilitating existing berms, and instituting a planting program to control berm erosion and provide shading to the Peconic River. In conjunction with the two experimental halls to be constructed, the tunnel would be completed at these locations.

<u>Environment Impacts</u>: The potential environmental impacts from the proposed construction and operation of the RHIC facility at BNL, as well as the cumulative effects from these actions are evaluated in the EA. Areas of potential environmental impact evaluated in the EA are air quality, noise, water quality and usage, aquatic and

terrestrial ecology, threatened and endangered species, land use, historical and archaeological resources, socioeconomic environment, radiological impacts, and potential impacts of accidents.

<u>Facility Construction Impacts</u>: Needed construction of the RHIC at BNL is limited to two research areas, utilities, and site work that would result in very little disturbance of previously undeveloped land. These construction activities would not generate radioactive waste. Restrictions such as diversion of storm water runoff to retention basins, immediate mulching and reseeding of disturbed areas, and the use of standard erosion control practices would be incorporated into project construction to eliminate potential impacts to ecological areas. No part of the proposed action would occur in a wetland. No significant impacts are expected on ecological resources.

Some portions of the RHIC project associated with the existing ISABELLE/CBA facilities would be within an area (i.e., the Peconic River) designated as "scenic" under the New York State Wild, Scenic and Recreational River Act. The ISABELLE/CBA facilities were constructed prior to the 1987 designation of the portion of the Peconic River flowing through BNL as "scenic". Impacts to the scenic resources of the Peconic River will be minimal. Construction and operation of RHIC will not affect the quality or physical nature of the River, either on the site or downstream. Most of the facilities required for RHIC have been completed and are visible from the Peconic River. Construction of the few remaining facilities will result in minimal additional visual detraction. There will be no impact on the scenic nature of the River itself as a result of RHIC activities. At the RHIC location, the Peconic River is an intermittant stream. The general public does not have open access to use and enjoyment of the River located within the BNL boundary.

Correspondence between DOE and the New York State Historic Preservation Office indicated that the RHIC project would have no effect on cultural resources. DOE has consulted with the State of New York on construction-related matters and will continue to do so. DOE will implement appropriate mitigation/protection measures that might be identified by the State during construction, as needed. These measures would be defined in conjunction with the State permit application process.

<u>Impacts of Facility Operation</u>: The RHIC complex would not have a significant effect on water consumption at BNL. Operation of the collider would result in a net increase in water usage of only four percent. This represents only three percent of BNL's margin of safe yield of 5,200,000 gallons per day. The RHIC is projected to require 27.7 MW of electrical power, with the injector system (AGS, Booster, etc.) using another 16.8 MW. Thus RHIC would add 70 percent to the total BNL peak load, an amount within the supply capability of present public utilities. Present estimates project

a three percent increase in steam production to meet the RHIC heating and air conditioning requirements. This increase is within the BNL's central steam plant reserve capacity.

RHIC operation would result in less than a five percent increase in the current amount (1500 tons) of solid waste generated by BNL; less than three percent increase in the current amount (45 tons) of hazardous non-radioactive waste generated by BNL; and less than five percent increase in the current amount (7300 cubic feet) of radioactive waste generated from all BNL projects. These increases would not be considered significant and, combined with waste minimization and recycling practices, should produce insignificant environmental impacts.

Four sources of potential radiological impact during RHIC operation were analyzed: 1) direct radiation; 2) skyshine; 3) releases of activated air from the tunnel; and 4) releases of radionuclides to the groundwater. The combination of existing (1.1 mrem/yr) and RHIC associated releases (0.77 mrem/yr) would be 50 times lower than DOE permitted limits (100 mrem/yr).

<u>Impacts of Accidents</u>: Three potential dose pathways (air, water, direct radiation) have been analyzed for accident scenarios. Accidental loss of the entire beam at a single point could produce a 34 mrem dose at the top of the berm. This could result in an off-site (at the site boundary) dose rate of approximately 0.009

mrem/event due to skyshine. In the Collider Center, the dose rate from direct beam radiation would be about 0.65 mrem/event, with another 0.09 mrem/event from the skyshine. The total dose rate in the Collider Center resulting from this accident scenario is 0.74 mrem/event. The RHIC facility, therefore, would be classified as a "Low Hazard" in accordance with DOE Order 5481.1B, Chapter 3(a)1. This designation applies to facilities which present minor on-site and negligible off-site impacts to people or the environment. There would be no identifiable incident for the water pathway. Assuming complete tunnel exhaust and minimum transit time off-site, the off-site dose due to an air emission incident would be 0.016 mrem. This value is well below the EPA annual dose limit from radionuclide emissions from DOE facilities of 10 mrem.

Impacts of Decommissioning: Potential environmental impacts of RHIC decommissioning would be fully assessed in a separate NEPA document. Decommissioning activities are not expected to result in any significant environmental impacts. Operation of the RHIC would result in potentially significant activation of only a few specific components and soil around the beam dump. If necessary during decommissioning, contaminated soil near the beam dump and activated components would be shipped off-site for disposal. Activated components would be categorized as low-level waste. Reuse or restoration of the RHIC site should be subject to no major complications, with negligible long term effects. Decommissioning of the RHIC, like RHIC construction and operation, would have no significant adverse environmental impacts.

Cumulative Impacts: No significant long-term or cumulative environmental effects are expected to result from the proposed action. Since the RHIC would utilize facilities constructed for ISABELLE/CBA, there would be very little disturbance of previously undeveloped land and no cumulative impacts from construction activities. The RHIC complex would not have a significant cumulative effect on water consumption at BNL, since operation would result in a net increase in water usage of only four percent. This represents only three percent of BNL's margin of safe yield of 5,200,000 gallons per day. The RHIC is projected to require 27.7 MW of electrical power, with the injector system (AGS, Booster, etc.) using another 16.8 MW. Thus RHIC would add 70 percent to the total BNL peak load, an amount within the supply capability of present public utilities. Present estimates project a three percent increase in steam production to meet the RHIC heating and air conditioning requirements, which is within the BNL's central steam plant reserve capacity. RHIC operation would result in less than a five percent increase in the current amount (1500 tons) of solid waste generated by BNL; less than three percent increase in the current amount (45 tons) of hazardous non-radioactive waste generated by BNL; and less than five percent increase in the current amount (7300 cubic feet) of radioactive waste generated from all BNL projects. These increases would not be considered significant and, combined with waste minimization and recycling practices, should not produce significant environmental impacts. RHIC releases and waste generation, in association with those currently produced by BNL, would not produce any potential cumulative impacts. The combination of existing BNL air releases (1.1 mrem/yr) and RHIC associated releases (0.77 mrem/yr) would be 50 times lower than DOE permitted limits (100 mrem/yr). Based on the analysis in the EA, there would be no potentially significant cumulative impact from construction or operation of RHIC at BNL.

Alternatives Considered: Alternatives to the proposed action that were discussed in the EA include the no action alternative, RHIC construction at another site or use of existing facilities elsewhere, and construction of a fixed target accelerator.

The no action alternative (i.e., not constructing and operating the RHIC, and maintaining the current status quo of ISABELLE/CBA) would result in not meeting the facility need requirements identified by the high energy and nuclear physics community and would forfeit the opportunity to venture into new physics regimes. Failure to pursue the RHIC program would render the existing ISABELLE/CBA facilities of little future use as an accelerator and would eventually result in the demolition of the facilities except for the Collider Center which provides useful office space. In the near term, the existing ISABELLE/CBA facilities would continue to be used as office space and storage areas.

Alternative siting of the proposed action evaluated in the EA was determined to be undesirable as no similar complex of existing facilities (AGS, Tandem Van de Graaff, and AGS Booster) exists. In addition, locating a RHIC elsewhere would necessitate the construction of a complete accelerator ring, with corresponding increases in expense and environmental impact.

Construction of a fixed target accelerator that can achieve collision energies of the magnitude intended for the RHIC would require an accelerator ring with a diameter approximately 400 times that of the proposed RHIC. Such a machine would be impractical in terms of cost, resource utilization, and environmental impact.

Determination: Based on the information and analyses in the EA, DOE believes that the proposed construction and operation of the RHIC at BNL does not constitute a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969. Therefore, an Environmental Impact Statement for the proposed action is not required.

Issued in Washington, D.C., this 6th day of December 1991.

Paul L. Ziemer

Paul L. Ziemer, Ph.D.
Assistant Secretary
Environment, Safety and Health